NASA: Engineering Space Exploration

National Aeronautics and Space Administration

Launching to the Moon, Mars, and Beyond

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C. Herbert Shivers, PhD, PE, CSP

Deputy Director, Safety and Mission Assurance Directorate

NASA/Marshall Space Flight Center

What is NASA's Mission?

- Safely fly the Space Shuttle until 2010
- Complete the International Space Station
- Develop a balanced program of science, exploration, and aeronautics
- Develop and fly the Orion Crew Exploration Vehicle (CEV)
- Return to the Moon no later than 2020
- Promote international and commercial participation in exploration

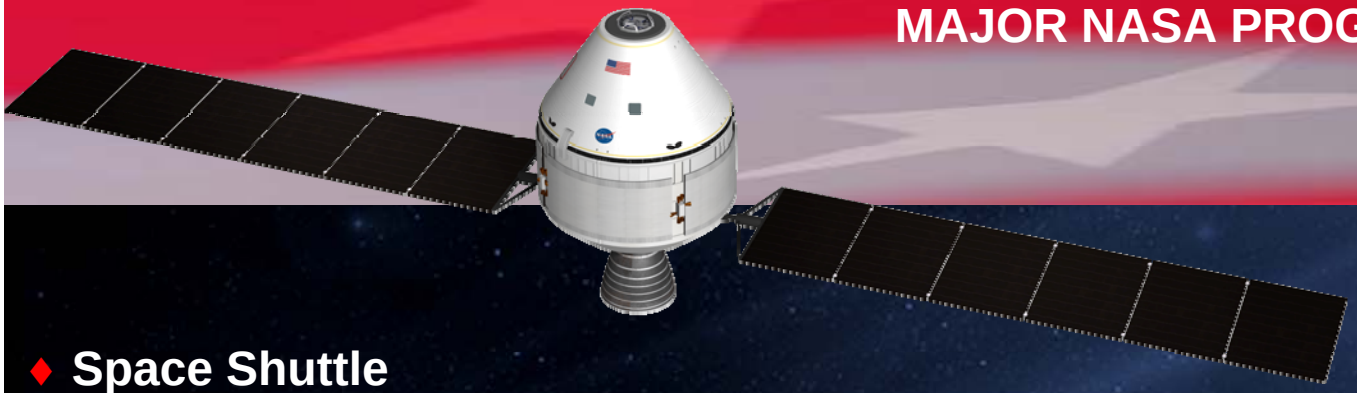
"The next steps in returning to the Moon and moving onward to Mars, the near-Earth asteroids, and beyond, are crucial in deciding the course of future space exploration. We must understand that these steps are incremental, cumulative, and incredibly powerful in their ultimate effect."

– NASA Administrator Michael Griffin
October 24, 2006

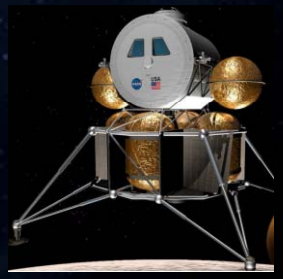
Why Do We Explore?

- **Inspiration**
  - Inspire students to explore, learn, contribute to our nation's economic competitiveness, and build a better future
- **Innovation**
  - Provide opportunities to develop new technologies, new jobs, and new markets
- **Discovery**
  - Discover new information about ourselves, our world, and how to manage and protect it

MAJOR NASA PROGRAMS



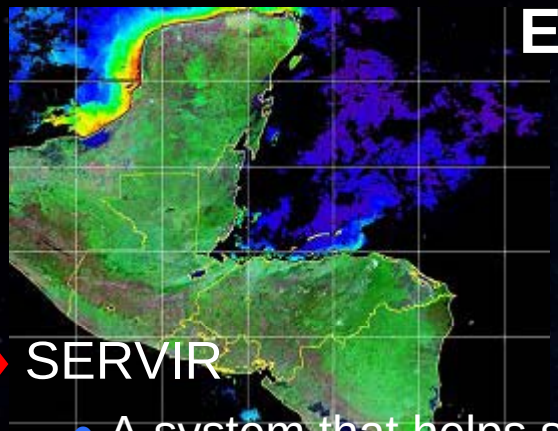
- **Space Shuttle**
- **International Space Station**
- **Earth and Space Sciences**
- **Constellation Program**
  - Crew Launch Vehicle
  - Cargo Launch Vehicle
  - Crew Exploration Vehicle
  - Crew Service Module
  - Earth Departure Stage
  - Altair Lunar Lander
  - Mars Transfer Vehicle
  - Mars Descent/Ascent Vehicle
- **Lunar Precursor Robotic Program**
  - Lunar Reconnaissance Orbiter (LRO)
  - Lunar Crater Observation and Sensing Satellite (LCROSS)



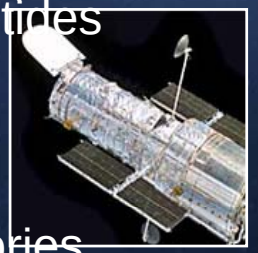
Space Shuttle

International Space Station

Earth and Space Sciences



- SERVIR
  - A system that helps scientists and authorities in southern Mexico and Central America identify sudden changes in environmental conditions, mapping details of deforestation, forest fires, hurricanes and toxic algae red tides
  - Beginning applications in Africa



- Hubble Space Telescope
  - The visible/ultraviolet/near-infrared element of the Great Observatories astronomical program.
  - STS 125 is the final servicing mission to HST
  - Extend its life and increase capabilities

- Other Space Telescopes – Spitzer, Chandra, James Webb (2013)

NASA's Exploration Roadmap

05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25…

Exploration and Science Lunar Robotics Missions

Lunar Outpost Buildup

Mars Expedition ~2030

Research and Technology Development on ISS

Commercial Orbital Transportation Services for ISS

Space Shuttle Operations

SSP Transition

Ares I and Orion Development

Operations Capability Development
(EVA Systems, Ground Operations, Mission Operations)

Ares I-X Test Flight April 2009

Orion and Ares I Production and Operation

Altair Development

Ares V & Earth Departure Stage

Surface Systems Development

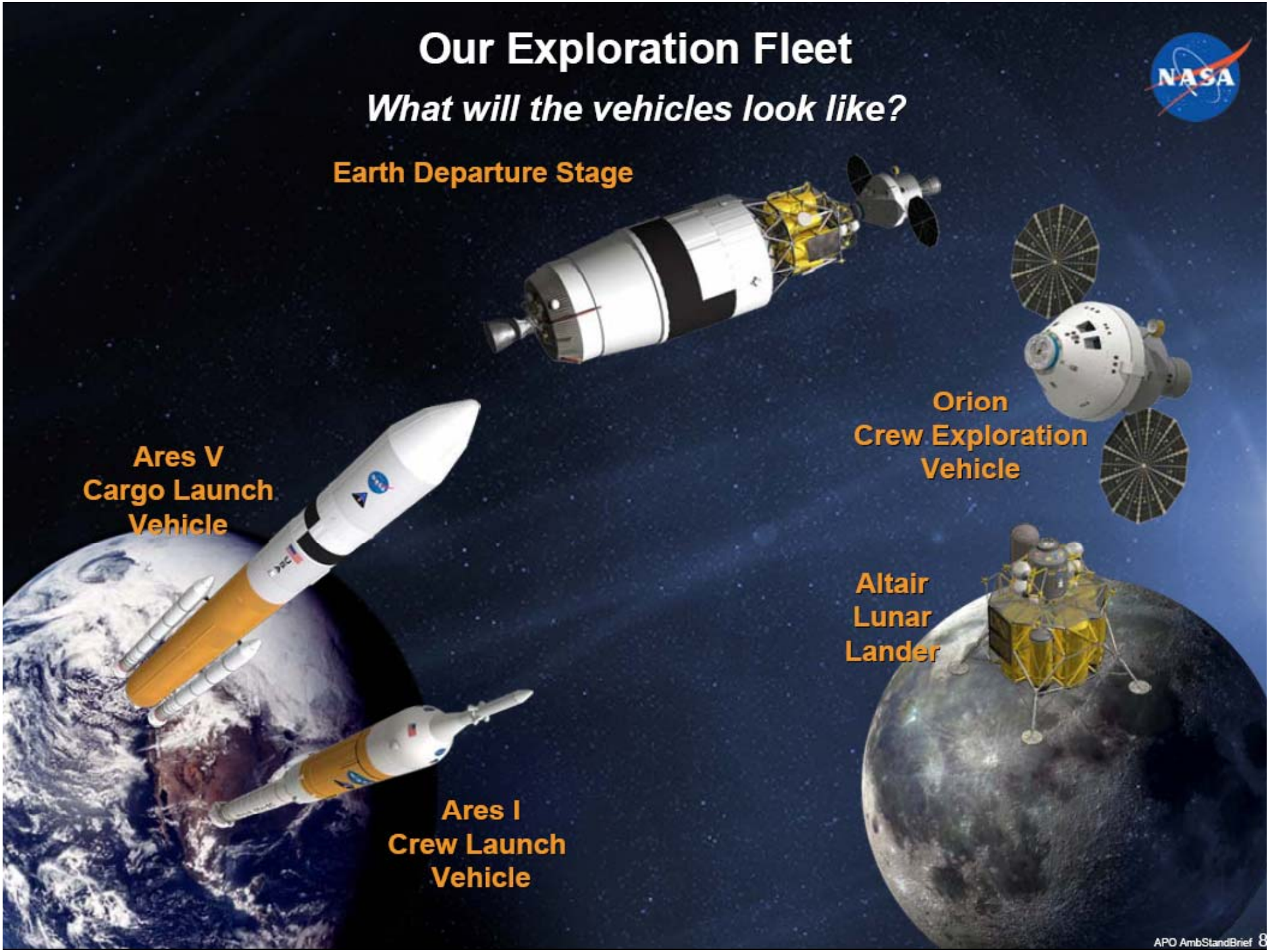
The Moon

- **Lunar missions allow us to:**
  - Gain exploration experience
    - Space no longer a short-term destination
    - Will test human support systems
    - Use Moon to prove ability to build and repair long-duration space assets
  - Develop exploration technologies
    - Launch and exploration vehicles
    - *In-situ* resource utilization
    - Power and robotic systems
  - Conduct fundamental science
    - Astronomy, physics, astrobiology, geology, exobiology

Next Step in Fulfilling Our Destiny as Explorers

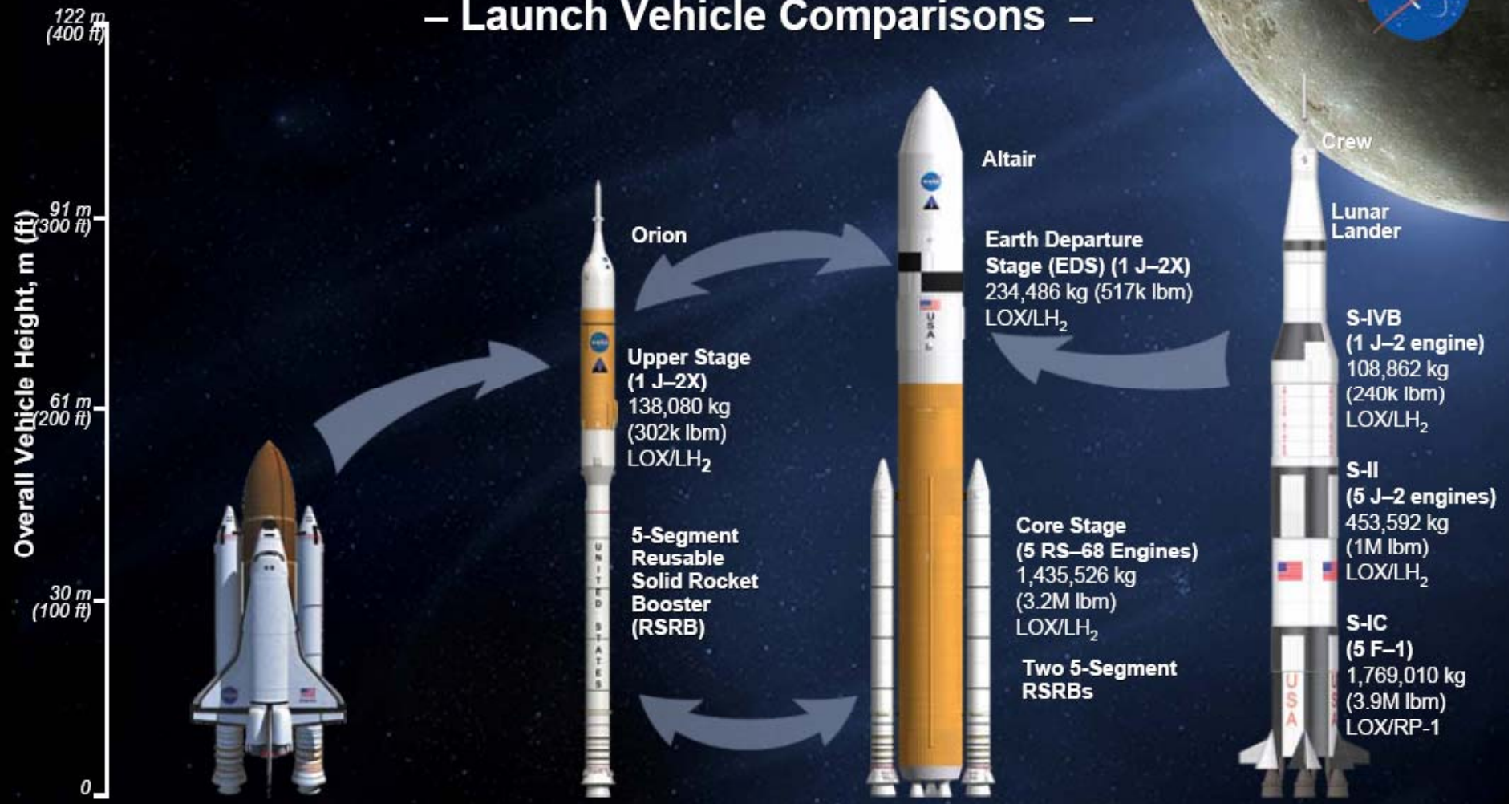
Our Exploration Fleet

What will the vehicles look like?



Journey to the Moon

Building on a Foundation of Proven Technologies
– Launch Vehicle Comparisons –



Space Shuttle
Height: 56.1 m (184.2 ft)
Gross Liftoff Mass:
2,041,166 kg (4.5M lbm)

25 MT (55k lbm)
to Low Earth Orbit (LEO)

Ares I
Height: 99.1 m (325 ft)
Gross Liftoff Mass:
927,114 kg (2.0M lbm)

25.6 MT (56.5k lbm)
to LEO

Ares V
Height: 109.7 m (360.5 ft)
Gross Liftoff Mass:
3,374,875 kg (7.4M lbm)

63.6 MT (140.2k lbm) to TLI (with Ares I)
55.9 MT (123k lbm) to Direct TLI
~143.4 MT (316k lbm) to LEO

Saturn V
Height: 110.9 m (364 ft)
Gross Liftoff Mass:
2,948,350 kg (6.5M lbm)

45 MT (99k lbm) to TLI
119 MT (262k lbm) to LEO

What progress have we made?

- Programmatic Milestones Completed
  - Ares 1 Systems Requirements Review
  - Ares 1 Systems Definition Review
  - Ares 1 Preliminary Design Review
  - Contracts awarded for first stage, J-2X engine, upper stage, instrument unit, and Orion
  - Ares 1-X test flight scheduled for Spring 2009
- **Technical Accomplishments**
  - First stage parachute tests
  - Developing first stage nozzles
  - J-2X test stand construction at Stennis Space Center
  - J-2x injector and power pack tests
  - Fabricating Ares 1-X hardware
  - Wind tunnel tests

Nozzle Process Simulation Article

Powerpack 1A Testing

Dome Gore Panel Fabrication

"Roughing" of 1% Model

go to www.nasa.gov/ares

- **First full-scale rocket motor test for the Orion spacecraft**
  - Test of a solid rocket that will be used to jettison the craft's launch abort system
  - Separates the craft's launch abort system from the Orion crew module during launch
  - The Orion launch abort system is a larger solid rocket motor system that will provide a safe escape for the crew in an emergency on the launch pad or during the climb to orbit
  - Completed March 2008

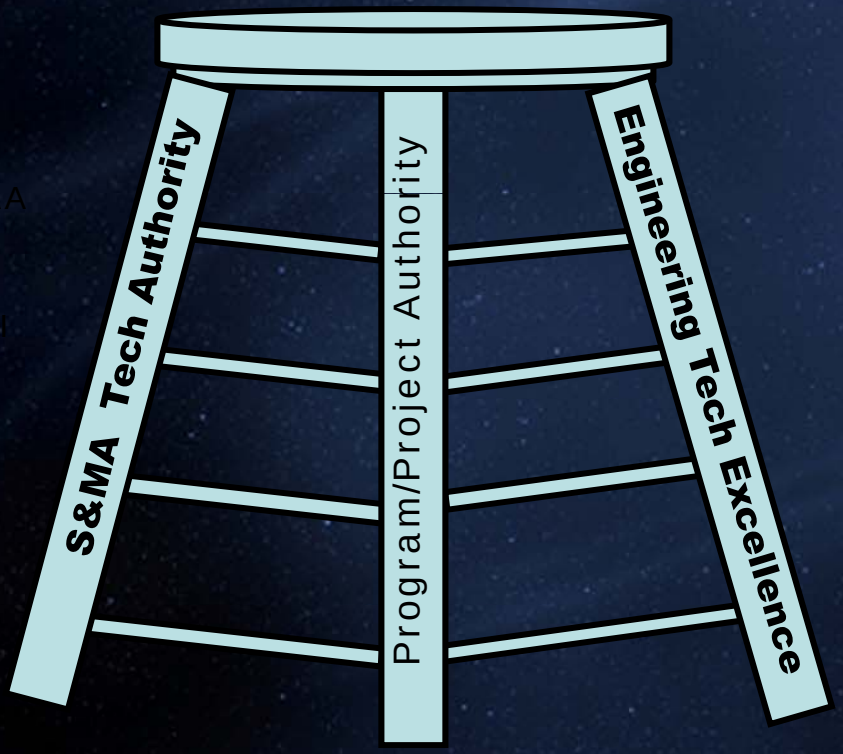
Ares I–X Test Flight

- **Demonstrate and collect key data to inform the Ares I design:**
  - Vehicle integration, assembly, and launch operations
  - Staging/separation
  - Roll and overall vehicle control
  - Aerodynamics and vehicle loads
  - First stage entry dynamics for recovery

- **Performance Data:**

	Ares I–X	Ares I
First Stage Max. Thrust (vacuum):	14.1M N (3.13M lbf)	15.8M N (3.5M lbf)
Max. Speed:	Mach 4.7	Mach 5.84
Staging Altitude:	39,624 m (130,000 ft)	57,453 m (188,493 ft)
Liftoff Weight:	834k kg (1.8M lbm)	927k kg (2.0M lbm)
Length:	99.1 m (327 ft)	99 m (325 ft)
Max. Acceleration:	2.46 g	3.79 g

-- Healthy Tension --
Technical Authority



The senior leadership at the Marshall Space Flight Center of the Ares Projects Office, the Engineering Directorate, and the Safety and Mission Assurance Directorate met on June 9, 2008. We, as senior leaders, agreed to the following tenets for success:

We are all committed to the success of the Ares I and V product lines. Ares is critical to executing the U.S. Space Exploration Policy and the core agency institutional capability required to develop future space systems.

We believe in a "YES, IF" versus a "NO, BECAUSE" culture – the goal is finding solutions to problems in a timely manner, within the constraints.

- A "win" means the overall program wins, not an individual or organizational win.
- We believe all team members need to be sensitive to the impact their actions have on technical, cost, schedule, and safety issues – these are all interrelated – nothing is "standalone." While each organization definitely has its primary leadership responsibilities, we all need to be cognizant of these constraints.

We value healthy tension to a constructive end. Asking tough technical questions to improve our products is expected at all levels and should always be done in a professional, "growing our team" manner.

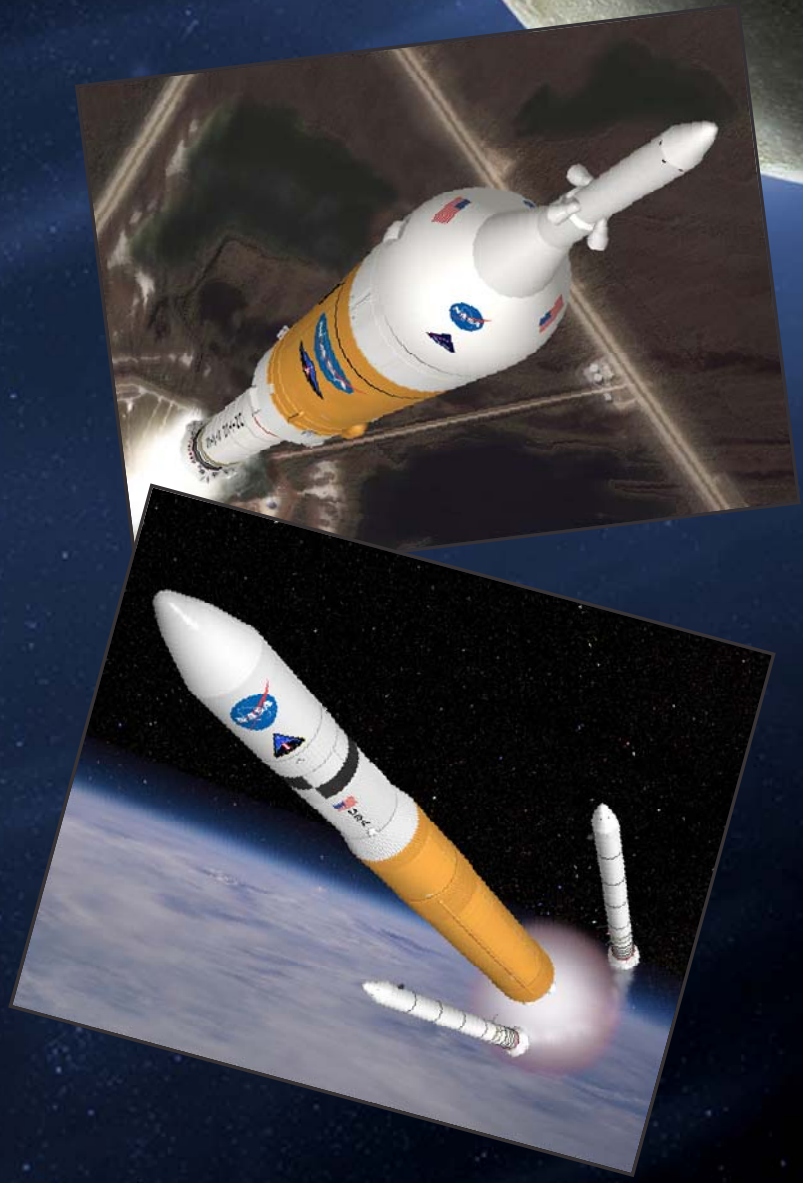
We need the team to work things through established processes before escalating issues. Not doing so is an unsupported work-around, causes churn in the system, and costs time and money.

We have five decades of spaceflight experience. Let's honor the good work of all those before us, take the best forward, and leave behind what does not work.

Team Tenets for Success

Summary

- Human beings will explore the Moon, Mars, and beyond to encourage inspiration, innovation, and discovery.
- We must build beyond our current capability to ferry astronauts and cargo to low Earth orbit.
- We are starting to design and build new vehicles, using extensive lessons learned to minimize cost, technical, and schedule risks.
- Exploring the Moon will help us reach Mars and beyond.
- Team is on board and making good progress – the Ares I-X test flight is on schedule for 2009.



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